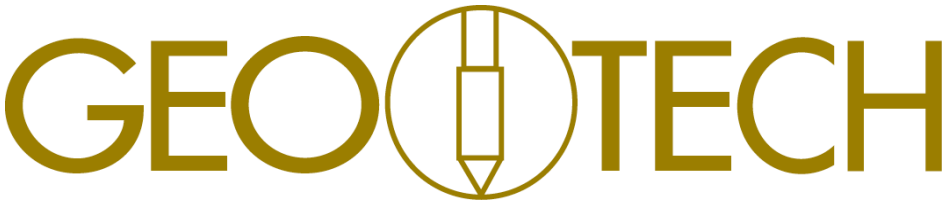
USERS MANUAL

NOVA Acoustic

CPT SOUNDING

(Cone Penetration Testing)



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1 THE GEOTECH CPT EQUIPMENT

1.1 Probes and Equipment available

The Geotech CPT equipment consists of the following main items:

Rigs or penetrometers:
- Multipurpose Penetrometer with 20 ton push force, model 220
- Continuous Penetrometer, 20 ton
- Multipurpose Site Investigation Rigs with 4 to 7 ton push force, models 504D, 604D, 605D, 607D, 707D

Geotech Probes:
- 10 sq.cm, with 20, 50 or 100 MPa Point resistance (Qc) range

- Most probes come with three (Qc, fs, u) or four channels (tilt in addition) -

Available channels:
- Point resistance (Qc), 20, 50 or 100 MPa range. Overload capacity: 25%
- Local friction (fs), 0.5 or 1 MPa range. Overload capacity: 50%
- Pore pressure (u), 2 MPa range. Overload capacity: 25%
- Tilt
- Temperature
- Seismic
- Electric conductivity

Area factors *(see calibration report)*: 10 cm^2 probes: Cone factor, a = 0.82, Sleeve factor, b = 0.0

Data Transmission: Digital. From probe to surface: RW (17), Acoustic (17 bit) or by cable (17 bit resolution)

Power supply:
- with RW and acoustic data transmission:
  -10 cm^2 probes: 4 alkaline, type “C” batteries (8 hours)
- with cable data transmission: via the cable

Extra features:
- Back-up memory of CPT data in cone (18 bit resolution)
- Alarm and emergency stop of push triggered by a preset maximum point resistance or tilt increment
- Mud lubrication of rods to reduce mantle friction

Data Logging:
- CPT: *CPT-LOG* (Windows) software running on PC notebook
- SCPT: *SCPT-DAA* (Windows XP, Vista) software on PC notebook

Data Interpretation:
- CPT: *CPT-PRO* by Geosoft, Geotech agent in Poland. Demo version at the Geotech site
- CPT: *CONRAD* by the Swedish Geotechnical Institute
- SCPT: *SCPT-DAA* as for the acquisition

1.2 Detailed part list

P.N.	Description
	I - Cordless CPT System: Minimum Kit Equipment
13595	*CPT Probe and depth synchronisation* Probe 3 channels (qc, fs, u) 10 sq.cm, 50 MPa, temperature compensated, tilt
10755	Depth synchronisation (wire)
10757	Cable depth synchr. to interface box
	Acoustic data transmission from probe
12451	Sound transmitter for 36 mm tapered thread rod, price per probe
08875	Microphone, top mounted, 20 ton
10662	Cable microphone to interface box
	Data acquisition and software
10660	CPT interface box for PC logging with CPT-LOG software
06975	Cable serial interface box to PC
41540	Cable power interface 12V
	Acquisition and Display Software for PC (Windows 95 or better)
08871	CPT-LOG
08527	Logging software for PC
10785	Transportation case for CPT probe
	Minimum set of spares
12425	Point, hardened steel
12428	Friction sleeve, hardened steel
10513	Filter ring brass
41380	X-ring
10702	O-ring, friction sleeve, set of 10
	Extension rods
07629	Tapered thread rods, 36 x 1.000 mm
09485	Transport case for extension rods (115 x 23 x 17 cm)
	II - CPT Probes
13595	Probe 3 channels (qc, fs, u) 10 sq.cm, 50 MPa, temp. comp., tilt
13596	Probe 3 channels (qc, fs, u) 10 sq.cm, 50 MPa, temp. comp., tilt, memory
13598	Probe 3 channels (qc, fs, u) 10 sq.cm, 100 MPa, temp. comp., tilt
13599	Probe 3 channels (qc, fs, u) 10 sq.cm, 100 MPa, temp. comp., tilt, memory

P.N.	Description
	III - 10 sq.cm Probe Spares
12425	Point, hardened steel
12428	Friction sleeve, hardened steel
41310	Filter ring brass
12429	Support ring to X-ring
41380	X-ring
10702	O-ring, friction sleeve, set of 10
13579	O-ring, battery pack
	IV- Back-up Memory
08969	Extra back-up memory module, for probe, 8 hours capacity
10661	Memory read out unit NOVA
	V – Sound transmission
00000	Mud adapter for microphone
00000	First extension rod w mud outlets
	VIII - Data Acquisition and Software
08871	CPT-LOG (Win 95 min, Pentium min), English version
	Interpretation program CPT-PRO by Geosoft
08882	CPT-pro, Interpr Mod, ver 5.31
08876	CPT-pro: Formula Editor
08883	CPT-pro: Cross-section module
10779	CPT-PRO Data editor
10604	Map LT

The Geotech CPT probes are equipped in their standard version with the following channels:

- 10 cm^2 probes: point resistance, local friction, pore pressure channels and tilt sensor.

Seismic adapter and electric conductivity adapter are options that can be mounted on Geotech CPT probes.

The above channels are described in the separate manuals for each adapter. Please refer to the given manual.

All items are described in the Geotech catalogue or on the Geotech web site http://www.geotech.se.

1.3 The Geotech cordless CPT System

Unless for special applications such as offshore or SCPT, most of Geotech clients choose to run CPT using the unique Geotech cordless data transmission system. This cordless system applies to all channels except seismic, i.e.: point resistance, local friction, pore pressure, tilt, temperature and electric conductivity.

GEOTECH started the development of cordless CPT system in the late seventies and the equipment was made operational in extensive offshore CPT surveys in the Canadian Arctic in the early eighties (*Jefferies M.G. and Funegard, E. (1983):* Cone penetration testing in the Beaufort Sea. Proc. ASCE Conf. Geotechnical Practice in Offshore Eng., Austin, Tx). The present equipment is a fourth generation and is still today unique on the market.

The system does not require a cable to transmit measured data, from probe to soil surface. This is done acoustically, i.e. the digitised coded data string is converted into a high frequency acoustic signal by a piezoelectric element in the probe. The signal is then transmitted up through the steel of the rods to a microphone on the rig or penetrometer. No cable is therefore used for transmitting the data from probe to the recorder at the surface. The absence of a cable makes the system very easy and time efficient to use.

From the microphone, the signals are transmitted to a computer interface box, which also receives depth information, from a depth encoder. The data is then sent to a PC notebook. The data are presented simultaneously on the PC screen as curves and digits.

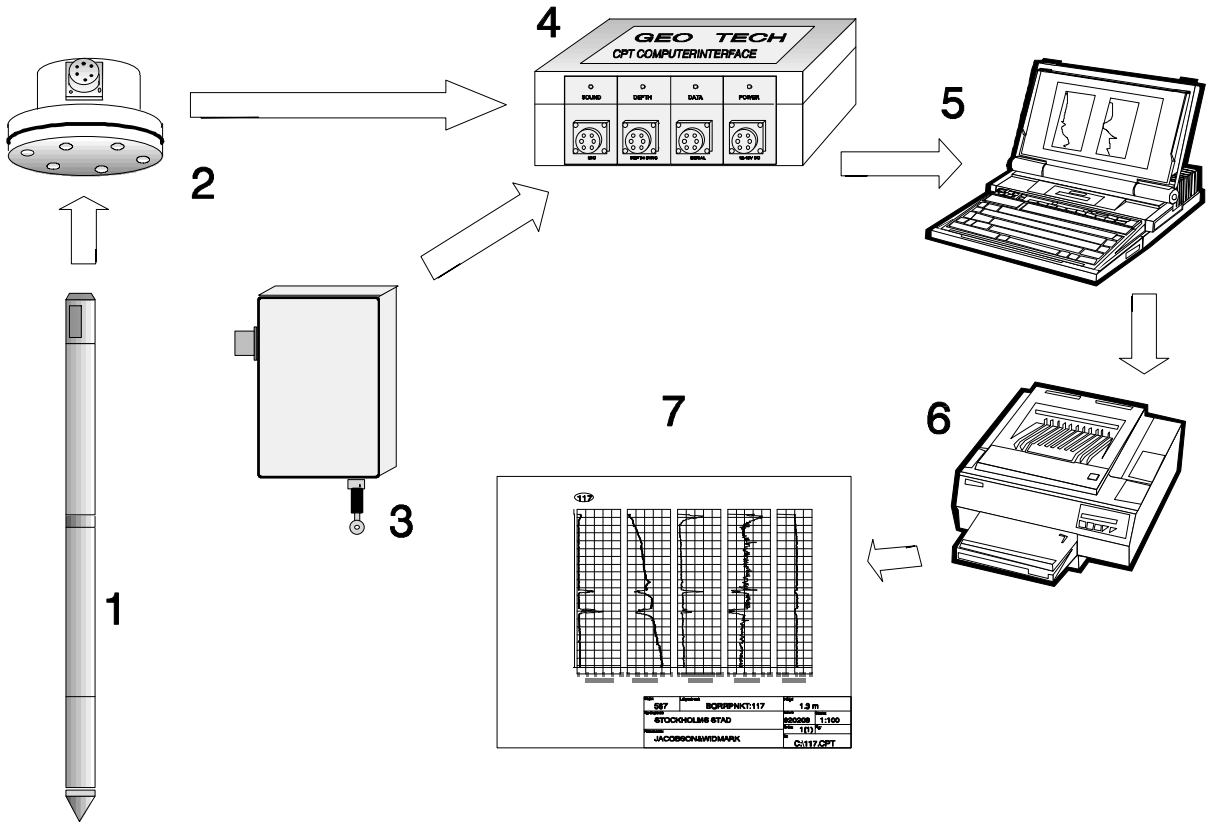


Figure 1: Description of the Geotech cordless CPT system
1.CPT probe 2. Microphone 3.Depth synchroniser or depth encoder 4.Computer interface box 5. PC Notebook 6. Printer 7. Results

1.4 Technical data

CPT probe
See special documentation

Sound Transmitter or Cable
See special documentation

Microphone
Weight 3,5 kg
Mud adapter 0,5 kg

Depth Synchronising Unit
Electrical-optical
Dimension 160x160 mm

Computer Interface
Dimension 170x210x55 mm
Weight 1,2 kg
Power 9-36 Vdc
Connection RS 232C 600-2400 Baud

Software requirement
CPT-LOG (Win): PC notebook with minimum 486 processor, 8 MB RAM, Windows XP, Vista

2 EQUIPMENT NEEDED

2.1 Checklist

A. PC Notebook, IBM or IBM compatible, Pentium minimum for CPT-LOG, 286 processor for CPTGL. Notebook excluded in sale.

B. Geotech CPT Interface box for PC logging.
Cable power interface 12 Vdc.
Cable serial interface box to PC.

C. Depth synchronisation unit (also called Depth encoder).
Cable depth synchronisation to interface box.

D. Microphone with mounting plate.
Cable microphone to interface box.

E. CPT(U) Probe (10 sq.cm) with Sound Transmitter.

F. Batteries, 4 pcs alkaline "C".

G. Calibration certificate for the probe and user manual.

H. Can with deaired points and deaired filter rings. Bring at least as many filter rings as the planned number of sounding during the day.

I. Container and funnel with glycerine. If a funnel with a 10 sq.cm bottom opening is not available, cut bottom and top (at approx. 10 sq.cm or 36 mm diameter) of a large soft drink plastic bottle

J. Drill rods, generally Ø36 x 1000 mm, tapered thread.

K. Pushing unit: penetrometer or geotechnical site investigation rig.

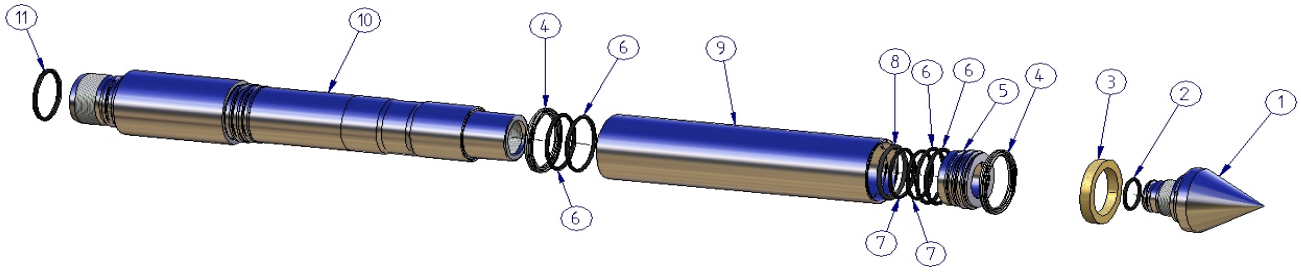
L. If required, anchoring equipment.

M. Logging software CPT-LOG.

2.2 CPT Probe

2.2.1 Geotech Probes

Figure 2: CPT Probe, 10 cm^2



Item	Description	P.N.	Item	Description	P.N.
1.	Point, 10 cm²	12425	7.	O-ring	13573
2.	O-ring	13578	8.	O-ring	13573
3.	Filter ring	41310	9.	Friction sleeve	12428
4.	X-ring	41380	10.	Cone body	12427
5.	Support ring	12429	11.	O-ring	13579
6.	O-ring	13576			

2.3 Transmitter

2.3.1 Transmitter for 10 cm^2 probes

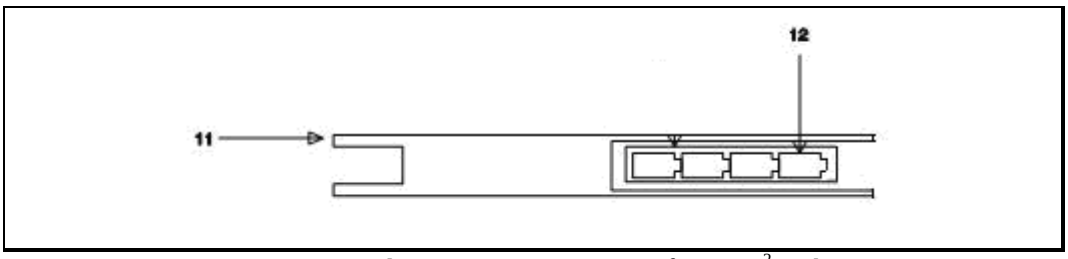


Figure 5: Sound Transmitter, P.N. 12451 for 10cm^2 probes

11. Serial number of the sound transmitter
12. Batteries 4 pcs "C" alkaline

3 PREPARATION FOR CPT SOUNDINGS

3.1 Step by step

1. Deair points, filter rings and grease with vaseline O-rings and X-rings at the office before CPT tests.

2. Keep the probe stored at a temperature as close to the ground temperature (+5^{o}C). The probes are equipped with a temperature sensor and a microprocessor to compensate for temperature variations. Nonetheless, the temperature drift is of <0.05%FS/ in the range of 0-40^{o}C for Qc, fs and u. For a 100 MPa probe (Qc range), this implies in summer (say +45^{o}C) a temperature difference of 40^{o}C and a drift 200 kPa.

3. Make certain that the motor, the hydraulic system and contacts between rod and kelly are not generating undue noise at a sound frequency similar to the sound transmission of the probe. This can have detrimental effect on the data transmission during the CPT test.

4. At the test site, prior to anchoring, auger a hole if the top soil consists of a dry crust or if CPTU will be carried out (CPT with pore pressure measurement).

5. If required, anchor the pushing unit and make certain that the pushing will be vertical.

6. Mount the depth synchronisation and microphone on the pushing unit. Connect power cable, microphone cable, serial cable and depth synchronisation cable to CPT interface box and notebook.

7. Introduce the probe in the funnel and water tight with tape. Deair the pore pressure chamber and mount X-ring, X-ring support, filter ring and point (10 cm^2 probes).

8. 10 cm^2 probes: Pre-stress the friction sleeve by tightening the cone tip by hand.
   Pull a condom on the probe, in particular if water is used in the pore pressure chamber.

9. Put fresh "C" alkaline batteries in the the transmitter. Observe that the batteries are installed in the right way, with the positive pole facing the probe. Mount the probe on the sound transmitter. Tighten by hand and not too hard.

10. Fill the hole with water.

11. Mount the first drill rod on the sound transmitter and start the software.

12. Follow the instructions from users manual of the software and start the CPT test after having punched the probe characteristics, calibration or scaling factors (in *.cpt files, abbreviated: KQ for point resistance, KF, for local friction, KU for pore pressure, O for temperature, A for electric conductivity and B for inversion factor for the electric conductivity) and checked the zero readings.

3.2 Explanations

3.2.1 Deairing

Glycerine is recommended rather than water. If water is used nonetheless, in winter time when temperatures are below zero centigrade, it could be necessary to add e.g. glycol to avoid the water from freezing.

Control that the filter ring and point are easily mounted on the cone before deairing. This will make the mounting easier.

Boiling

The glycerine should be deairated by boiling at least 15 minutes. This can be done together with the points and filter rings. Take at least as many points and filters that will be used during one day. Keep the filters and points in the liquid until they will be used.

Vacuum treatment

Put the points and filter rings in the tank of the vacuum pump. Fill the tank with glycerine so that the content is covered. Connect the pump and deair for about one hour. Be observant so no glycerine is sucked into the pump. This could damage the pump. If too little glycerine is used it could boil away. Keep the filters and tips in the liquid until they will be used.

Deairing on the site

If you have forgotten to deair the tips and filters, or if you want to use already used tips it can be done in the field. This is not a recommendable method. but it works tolerably.
Put a deairing funnel over the cone and fill it with water. Mount and dismount the tip at least 20 times. Refill with water all the time. Have washing-up liquid added.

3.2.2 Pre-augering

In order to obtain good quality pore pressure measurements, pre-drilling must be carried out all the way down to the ground water table.

If the first meters consist of dry crust with clay or silt, pre-augering down to 0,5 - 1,0 m could be enough.

If the first meters consist of fillings, pre-augering is recommendable through the whole filling. If the soil seems to collapse into the hole it must be stabilised with a casing or e.g. bentonite. If a casing is installed it must than be filled up with water.

During winter time when ground frost is present, pre-augering must always be carried out. If the probe is pressed through soil frost, there will be an under pressure which can suck the water out of the filter. This will cause a generated pore pressure curve that is very inaccurate.

3.3.3 Anchoring

The pushing unit, e.g. penetrometer or site investigation rig, has to anchored to the ground if its weight is lower than the available feeding force and lower than the expected reaction force, it could be advisable to anchor the unit.

Different augers are used for different types of soils. If the soil surface consists of clay or mainly clay, anchoring augers with large diameters are preferable. Suitable diameters are between 100 mm and 200 mm. If the soil surface consists of non-cohesive soils augers with a smaller diameter are sufficient but may have be driven down to a layer with sufficient reaction force.

If the torque needed to drive the augers is very high, it could help to lubricate the augers e.g. with bentonite.

3.3.4 Depth Synchronisation Unit (DSU)

The Depth Synchronisation Unit comes as a spring loaded string pot or as a wheel rolling on the rods.

For the spring loaded string pot, weld or screw the mounting-plate in a suitable position on your pushing unit and arrange for a hook e.g. screw. The Depth Synchronisation Unit and the hook should be mounted n a moving respectively fixed item, or inversely. Make however sure that the wire runs in a straight and vertical line all the way to ensure correct depth registration. It is preferable to protect the wire from grease, dirt and water.

The rolling wheel model has a wheel rotating against the extension rods. The unit is mounted so that a firm and constant contact between rods and wheel is ensured.

3.3.5 Microphone

The contact surface at the end of the rod string where the pushing action is transmitted is the microphone. The microphone should therefore be mounted under the pushing. It is essential that good mechanical contact is achieved in order to guarantee the sound transmission.

Geotech can provide a device for those who wish to use a rotary unit and chuck to tighten and loosen rods.

3.3.6 Batteries

The 10sq.cm probe is powered by 4 pieces of alkaline "C" batteries. The lifetime of this power pack is normally around 12 hours. The lifetime is shorter if the probe is operating at lower temperatures than the normal soil temperature e.g. if the probe is operating for long time in the air when it is freezing. The voltage should always be checked and for is for fresh batteries 6 Vdc. Check prior to all soundings the voltage, as the probe stops functioning at a voltage lower than 4.5 Vdc.

Use only hand power to tighten the cone to the sound transmitter. In spite of this it could be necessary to use tools to dismantle the probe after the sounding. High point resistance could tighten the probe quite hard.

3.3.7 Saturating the pore pressure chamber and mounting point and filter ring

Introduce the probe in the funnel (or a cut plastic soft drink bottle) and water tight with tape. Fill with glycerine and place a deaired a point, an X-ring, an X-ring suppor and a filter ring.

Carefully remove all air bubbles in the pore pressure chamber with a syringe or a needle. This will take at least 10 minutes if the probe is new.

Mount the X-ring on the support ring and place them on top of the probe, then the deaired filter ring and the point.

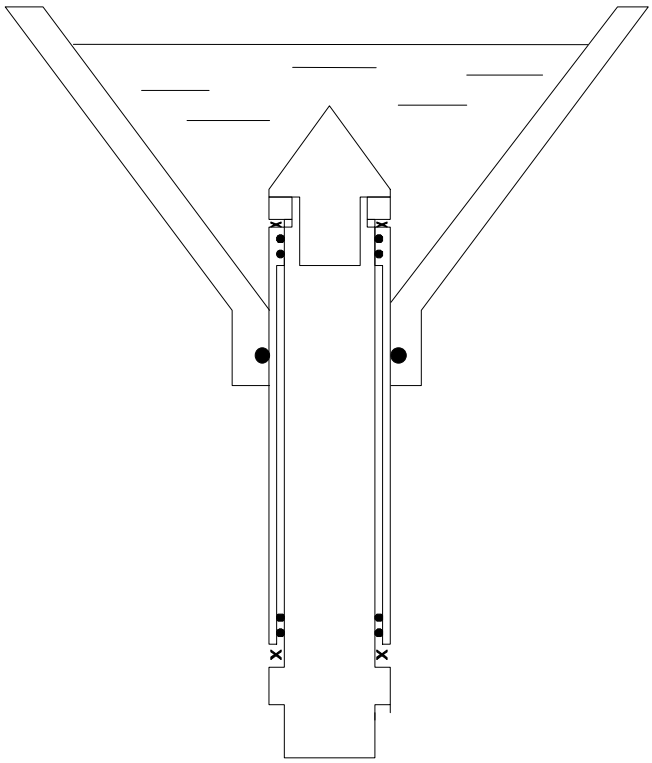


Figure 6: Deairing the pore pressure chamber and mounting the X-ring, filter ring and point

3.3.8 Use of slot type filters

In unsaturated soils and soils where negative pore pressures are generated during penetration, conventional filters may loose their saturation and not respond to pressure changes, see Fig. 7 below. While this loss of saturation is permanent when penetrating unsaturated soils, it returns to normal in the second case provided the pores of the filter have not been clogged with soil particles.

For shallow layers, the loss of saturation can be avoided by pre-drilling and filling the hole with water. The alternatives to porous filters are slot type filters with the pore pressure chamber filled with grease.

The cause of loss of saturation when negative pore pressures are generated is the formation of gas, due to the lowering of the evaporation temperature of glycerine and even more of water when the pressure is reduced under the atmospheric pressure. With a pressure reduction of 70-80 kPa below atmospheric pressure, water or glycerine starts boiling (Larsson, 1995).

This will not occur when filling the pore pressure chamber with grease, using a slot type filter, unless air bubbles remain trapped in the grease.

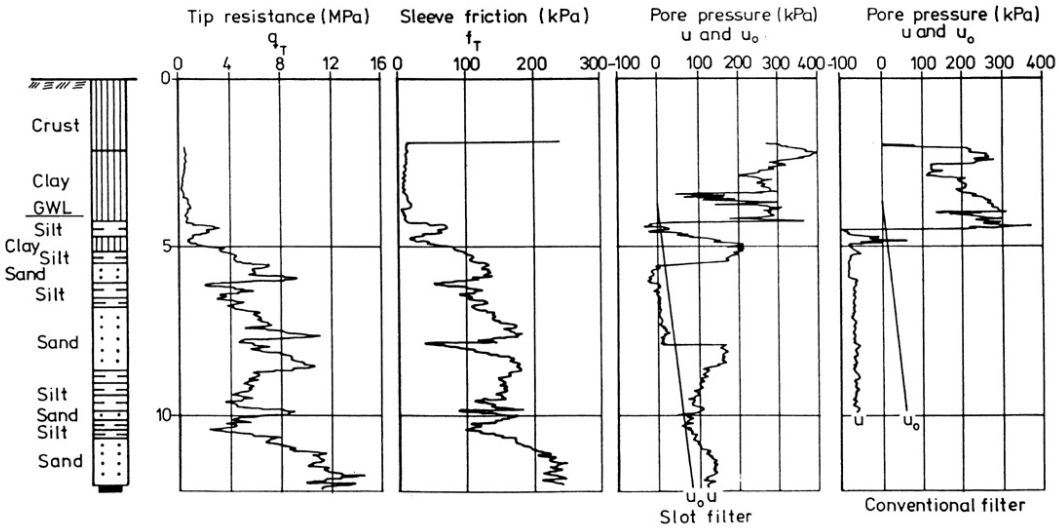


Figure 7: Example of CPTU sounding run with us filter and grease filled slot filter: vacuum is generated at 4.5 m with a conventional filter whereupon is ceases to function. The slot filter registers overall larger amplitude variations, including lower negative pore pressures. (Larsson, 1995).

The slot filter is equipped with a support ring for the X-ring and is mounted on the CPT tip. The pore pressure chamber is filled with grease as follows:

1. Fill the chamber and the inside of the tip with grease.
2. Mount the tip and slot filter with an X-ring on the cone
3. The chamber and filter become automatically saturated, with excess grease squeezed out in the slot

4. No protection has to be taken with the cone as the stiffness of the grease will prevent it from flowing out.

The choice of grease must be made carefully:

- With a firm grease, zones and layers of unsaturated soil or where negative pore pressures are generated, can often be passed without loss of saturation. The disadvantage is an evening out of pressure variations
- With a softer grease, this advantage is lost, and the same problems with saturation as with normal fluid saturated filter will occur.

The following are a few tested greases (Elmgren, 1995), giving ±1 kPa hysteresis between on- and offloading curves:

- Statoil LK 62
- BP LT2
- Ariens moly No 1

The corrected tip resistance q_T and sleeve friction f_T are essentially unaffected by the types of filter and fluid used.

Elmgren, Kjell (1995): Slot-type pore pressure CPT-u filters. Behavious of different filling media. CPT'95 - International Symposium on Cone Penetration Testing. Linköping 4-5/10 1995. Vol. 2, p. 9-12

Larsson, Rolf (1995): Use of a thin slot as filter in piezocone tests. CPT'95 - International Symposium on Cone Penetration Testing. Linköping 4-5/10 1995. Vol. 2, p. 35-40

3.3.9 Pre-stressing the friction sleeve (10 cm^2 probes)

Remove the funnel and tighten the cone firmly, but only by hand. This will provide a pre-stress on the friction sleeve with approximately 5 kPa. When, later on, the probe is pushed into the ground the tip will be tightened harder. The tip will not loosen, unless the probe is turned anticlockwise in ground.

When the tip is tighten, the filter ring will pressing on the lower X-ring (close to the point) which will then press on the friction sleeve. The sleeve, in turn, is pressing on both the upper X-ring (towards the sound transmitter) and the local friction sensor inside the probe. **This initial pressure will remove any slip between sleeve and the local friction sensor and is paramount in order to measure small frictions and to avoid non-linearity at small loads**.

This initial pressure on the local friction and cone resistance sensors is static and will not change during the penetration of the soil, unless the sealing leaks. Finally, this pressure is tarred when the zero values of the sensors are read before the start of the test and it will therefore not affect the readings.

It is important that there is an initial load of approx. 5kPa on the local friction sensor before the zero reading of the sensor. If not, the friction sleeve may not be in contact with the sensor, resulting in a gape which will give the friction reading.

3.3.10 Other Channels: Tilt, Temperature and Electric Conductivity

The tilt channel does not require any special care nor is it recalibrated. It is mounted in the electronic part of the probe, above the friction sleeve, approximately 7 cm from the upper end of the probe. The temperature sensor, independent from the sensor for temperature correction in the probe of all CPT measurements, is mounted in the electronic part of the probe as well, 2.5 cm above the friction sleeve. Temperatures are recorded in degrees centigrade. The sensor is recalibrated together with the other CPT sensors

For the seismic adapter, please refer to the given manual.

3.3.11 Zero Readings

Start the computer and input the probe characteristics, calibration values and start a CPT test by following the instructions in the manual and on the screen displays.

Check the zeroes by holding the probe by hand against the microphone. The probe should not be subject to any load. Do not therefore:

- Let the probe rest on the ground, loading the point
- Introduce the probe in water, loading the pore pressure sensor
- Hold the probe by the sleeve friction.

It is important that the zeros are read with the probe holding a temperature close to the soil temperature as the temperature drift is largest source of measurement error (Non linearity for the point resistance: <0.1%FS, with temperature stability <0.05%FS/10^{o}C).

It is recommended that the probe and transmitter have been connected at least a minute before zero readings is made.

More background information is found at the end of the manual.

3.3.12 CPT SOUNDING

Start the CPT sounding. At the end of each stroke, pull the yoke or drill head back up and add a new rod **without** going into PAUSE mode.

Both CPT-LOG and CPTGL can monitor dissipation tests.

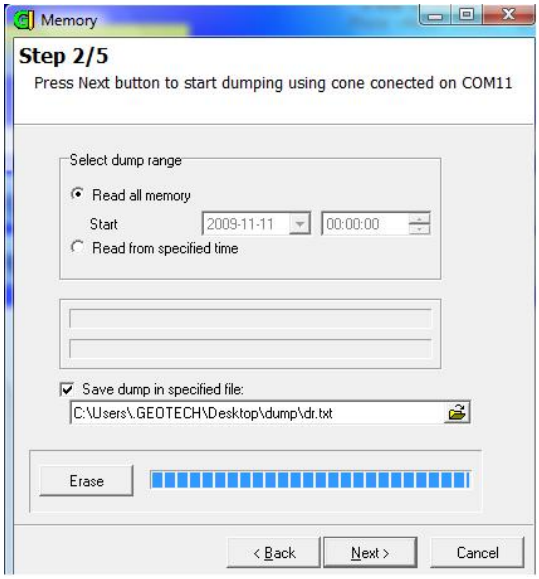
At the end of a sounding never stop the logging software. All soundings must be terminated with a second zero reading once the probe is retrieved from the ground. This is to check any sensor drift.

The data cannot be displayed with the software without zero checks before and after testing.

4 USE OF CONES WITH A BACK-UP MEMORY

The Geotech CPTU probes can be equipped with a back-up memory of minimum 36 hours capacity and 18 bits resolution.

The purpose of this back-up memory is to guarantee a data logging in case of losses of data with the cordless data transmission, due to high ambient noise levels when penetrating dense sands, acoustic interferences on the pusher or due to too large penetration depths. Failures in the data transmission can be observed as straight lines on all channels in the recorded profiles.



4.1 CPT soundings with cones with a back-up memory.

They differ only slightly from the procedure with a standard cone. Only the differences are therefore described here.

1. After starting the CPT acquisition software, CPT-LOG, make certain that the cone is defined as a “Back-up” type in the “Cone Database” module.

2. Connect the memory read-out cable in the probe and lap top.

3. Start the “Penetration” module, press F1 – New (Sounding).

4. Go to Options → Cone synchronization and wait for the synchronization to finish.

5. Continue the sounding as normal.

This procedure is not necessary to be done before each test unless lap top is exchanged but it is recommended to be done first test of the day.

Once the memory is filled it will overwright the first sounding and continue in a loop.
By request it is possible to set an overwright protection on the back-up memory.

Data retrieval

At the end of the test or of the day, you can (if necessary) transfer the data saved in the back-up memory to your lap top.

1. Connect the memory read-out cable to your probe and lap top and start the “Back-up Memory” module of the CPT-LOG software.

3. Follow the instructions in the “Memory” window that shows.

Since no depth and time is recorded in the back-up memory the file needs to be synchronized with the original file saved on your lap top. The new CPT files are labelled as the original ones but with a “*_m.cpt”. More information in the CPT-log manual.

The memory is emptied when all data are transferred or when “Erase” is pressed.

All data are always stored in a “dump.txt” file.

5 AFTER THE CPT SOUNDING

5.1 Cleaning the probe

After sounding, it is very important to clean the probe. Dismount the point and filter ring from the cone and put them in a tank with water so they don't get dry. Dry soil is very hard to get rid of from inside the filter.

Dismount the friction sleeve by careful rotation and pull it off. Clean the O-rings and the X-rings both under the sleeve and on the cone. Wipe the moisture away. If it is wet under the friction sleeve, water has penetrated under the O-rings. They are damaged and must be replaced. Lubricate the X-rings and the O-rings slightly with Vaseline and mount the friction sleeve. The sleeve is now easily turned.

If the X-rings and O-rings are not clean, this may affect the local friction readings.

When the probe is pulled back from the ground, soil could penetrate above the upper X-ring which will force the friction sleeve downwards. During the next sounding the friction from the soil must first press the soil out from the X-ring before the measuring is started.

6 INSTALLATION DESCRIPTION

6.1 Depth Synchronisation Unit

The DSU is initially made to give increasing depth when the wire is going inwards. If you desire the reverse (e.g. increasing depth when the wire is pulled out) you swap the wires on pin B and pin C in the cable connector that is connected to the interface. The DSU should be mounted so that the wire runs downwards, to avoid water entering the box.

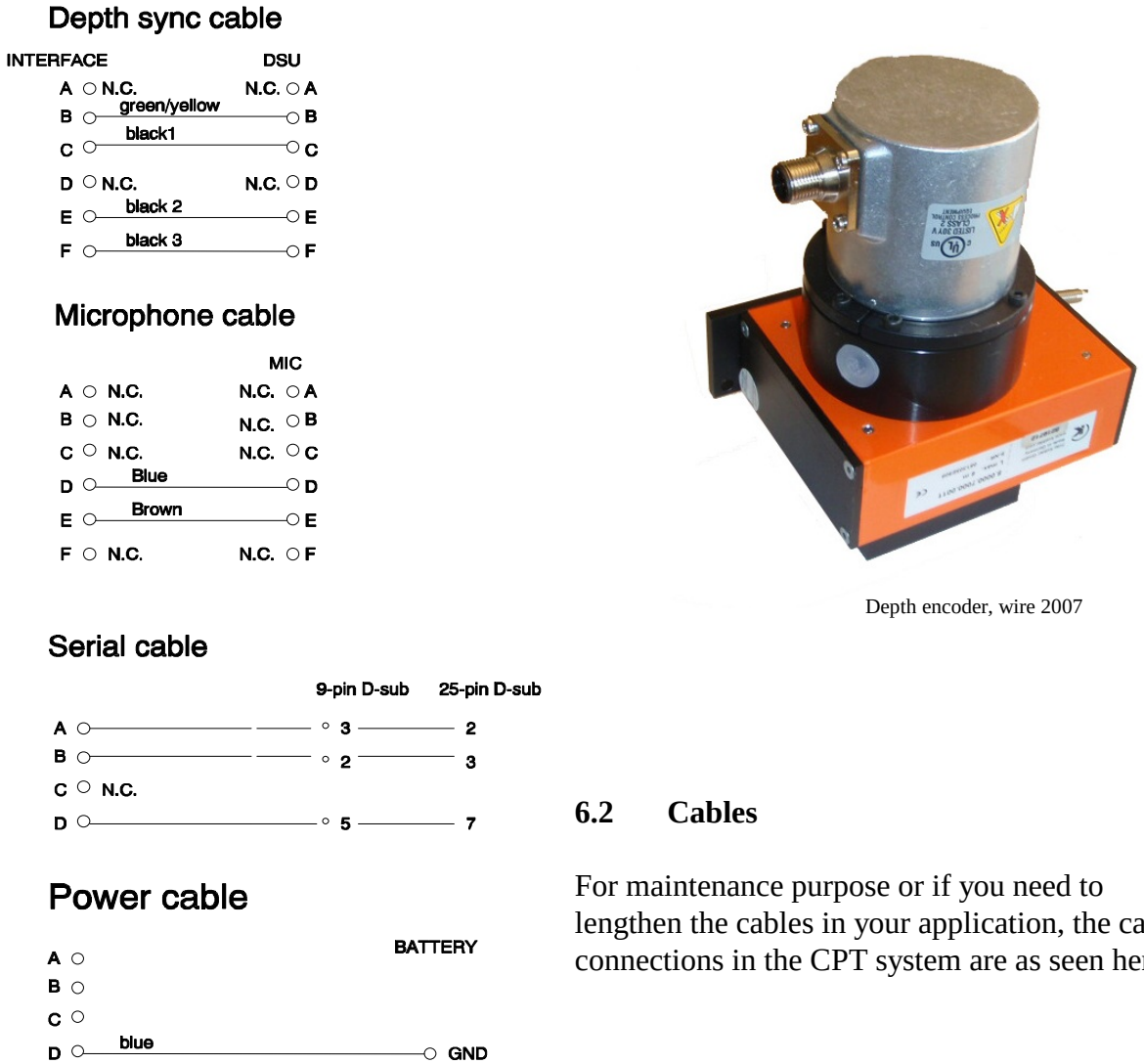


Figure 10: Cable connections

Depth encoder, wire 2007

6.2 Cables

For maintenance purpose or if you need to lengthen the cables in your application, the cable connections in the CPT system are as seen here.

6.3 Overload control card

The Geotech Overload Control Function is used for CPT soundings with the Geotech cordless Cone Penetration Test (CPT) system.

The CPT operator can pre-set a maximum point resistance (Qc) and/or tilt increment at which the cone penetration will automatically be halted in order to avoid damaging the probe. This can occur when the probe hits a stone or gravel or slants on its side. In particular, bending of probes can occur within a few centimetres slanted pushing.

6.3.1 Mounting Instructions

1. Connections to the penetrometer: The overload function is a single pole switch, type SPCO which can be used to either close or open an electrical circuit, such as an electrically controlled hydraulic valve. I.e., the penetrometer has to have an electrically controlled hydraulic valve to activate the pushdown of the yoke.
2. Add extra 2 wire-cable to the female contact of the power cable (we can supply you with this).
3. If the hydraulic flow is stopped by disconnecting the electric circuit, i.e. disconnecting the electrical power to the valve, use the pins ”A” and ”F” on the female connector.
4. If the hydraulic flow is stopped by closing the electric circuit, i.e. connecting the electric power to the valve, use the pins ”A” and ”B” on the female connector.

When uncertain, please send us the electrical circuit diagram of the rig and we will give you a more detailed answer.

6.3.2 Use of the overload control card with the CPT logging software

The maximum point resistance and tilt increment values are set in the logging software CPT-LOG (Windows XP, Vista).

When the recorded point resistance or tilt increment value exceeds the pre-set values, the software goes into PAUSE. This gives the operator the choice to stop the sounding or continue, at his risk.

6.3.3 Recommendations

- Maximum point resistance value: The cones have a safety factor of 50%. Therefore never exceed 25% of the point resistance range.
- Tilt increment: For space reasons, the tilt sensor is placed in the electronic part of the probe, i.e. 20 cm from the porous filter. Once the probe is introduced in the ground, use therefore small tilt increment values (in the range of 0.5^{o}/cm or 50^{o}/m).

7 Calibration, Sensors and Sealing

7.1 Calibration codes

Each channel has a calibration code, which is a scaling factor (amplifying factor) for the measured value. The calibration code can adopt values from approx. 400 up to 9999, and doesn't affect the zero value (offset) of the gauge.

The sensitivity of the sensor can be changed by changing the calibration code. If the calibration code is **increased**, the sensitivity of the sensor will be **decreased** (lower gain).

To check that the measured value from the CPT-probe is correct, the CPT-probe should be loaded in a loading frame and the read-out from the CPT-probe should be compared with the read-out from an accrue load cell. If the value differs, a new calibration code can be determined from the following formula.

$$Cn/Co=Pr/Pl$$

Where: Co is the old calibration code.
Cn is the new calibration code.
Pr is the read-out value from the CPT-probe.
Pl is the loaded value on the load cell.

The relation between the read-out value from the CPT-probe and the load cell is not a linear function for the pore pressure and the friction sleeve sensors. Therefore, the calibration code is only valid for a certain load. When determine a new calibration code, the corresponding load on the CPT-probe should be in the area where the highest accuracy is needed. Sometimes it can be necessary to use different calibration codes for different soundings, depending on soil conditions.

When loading the sensors of the CPT-probe, it is important to point out following details:

- The probe should be loaded with friction sleeve, filter ring and cone tip and all X- and O-rings mounted on the probe. The probe and its parts should be well cleaned and all sealing lubricated with Vaseline. The cone tip should be tightened by hand and the friction sleeve turned half a turn to centre between the sealing. Turn the friction sleeve the right way. Wrong way will loosen the cone tip.

- If the cone tip needs to be dismounted, to load the friction sleeve, the upper x-ring must also be taken off.

- When loading the pore pressure sensor, the other sensors should also be set under the same pressure. The reason for this is that crosstalk can be measured so net area factors for local friction and cone resistance can be determined.

- When loading local friction and cone resistance it is important that the load is applied straight in line to the probe to avoid bending. This is for safety reasons and to avoid the influence of bending to the sensors during the calibration procedure. The adapters provided by Geotech AB, or similar, should be used when loading the sensors on the probe.

7.2 Sensors and sealing

The sensors on the CPT-probe are operating in a difficult environment and therefore special demand is required.

General description of the sensors

The friction sleeve is mounted at the lower end of the probe. Between the sleeve and the probe is a double O-ring sealing to prevent water to leak in under the friction sleeve. At both ends of the friction sleeve an X-ring is mounted. They prevent the soil to act on the ends of the friction sleeve, but they are not intended to seal for neither for water nor air.

The lower X-ring (close to the filter ring) is attached to a support ring (washer). The support ring has three major tasks:

1) To prevent the filter ring to press on the friction sleeve.
2) To hold the X-ring
3) To prevent the friction sleeve to be pressed downwards and cause damage to the lower X-ring during the pull back after each test.

At this lower end of the probe, the point with the filter ring is mounted.

The pore pressure sensor is located inside the cone resistance sensor. The cavity between the pore pressure sensor and filter ring (pore pressure chamber) and the filter ring should be saturated with liquid to have the necessary response.

All sensors are arranged on the probe in order to minimise the influence between the sensors.

To obtain repeatable results, it is very important that the O-rings seal for water and the X-rings for soil. Therefore all sealing in the probe are set under initial stress. If not, **they will not seal**!

In addition, **O-ring sealing will always leak if damaged or dirty**. When replacing O-rings, lubricate with Vaseline, and mount the friction sleeve carefully.

Because of tolerances in the manufacturing procedure of the CPT probe, the friction response should always be checked when the friction sleeve is replaced.

7.3 Zero readings

After each test in the field and after the probe has been pulled out from the ground, the zero values of the sensors should be compared with the zero values taken before the test was started. If the difference is small, for the cone resistance and local friction, the conclusion is that it has not been any damage to the sensors and the sealing had worked correctly during the test.

If there is a difference between the zero readings before and after the test, for the cone resistance and local friction, it could be caused by the following reasons.

1) Overload of the sensors due to high loads or strong bending of the probe.
2) The sealing has been leaking. Soil between the x-rings and the friction sleeve causing higher loads on the ends than the initial load.
3) Different temperatures in the probe before and after the test in combination with significant temperature drift in the sensors.
4) If the tip, for some reason, is taken off or just unscrewed a little, the initial load on the sensors will also be removed or reduced.

The zero readings from the pore pressure sensor suffer from a different problem. During the pull back after each test, sometimes very low pressure can be generated. If so, the filter ring will drain from liquid and replaced with soil. The soil will seal off the pore pressure gauge from the surrounding pressure.

The result of this is that when the zero readings after test is taken, with the tip still on the probe, the pressure on the sensor will not be atmospheric. To read the correct unloaded pore pressure value (zero reading) the tip must be removed from the probe. However, if the tip is removed, the initial load of the cone resistance and local friction sensor is removed.

Therefore, two zero readings should be taken after the CPT test. One with the tip mounted on the probe and one with the tip taken off from the probe.

8 SPECIAL APPLICATIONS

8.1 CPT Soundings with cable mode data transmission

In CPT soundings where it is preferred to use a cable, the same probes, depth encoder and interface box are used. Needed in addition are:

- a cable adapter on the probe,
- cable of sufficient length,
- an adapter between the end of the cable and the interface box

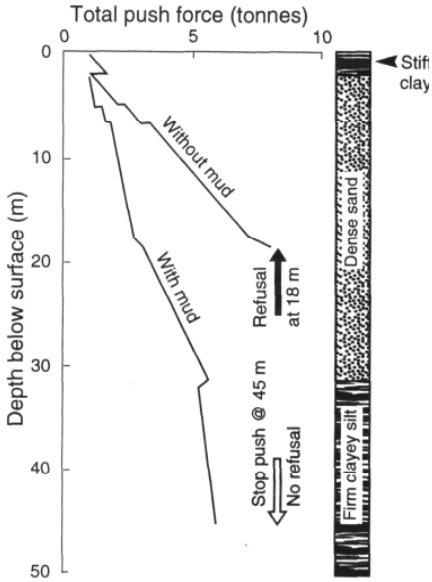
The sound transmitter and microphone are not used.

The cable is threaded through the extension rods prior to the sounding. The two leads of the cable are then connected to the signal conditioning box*: lead 1 to socket 1 and lead 2 to socket 2*.

Seismic CPT tests (SCPT), done with the Geotech seismic CPT adapter, can only is run with a cable due to the density of incoming data. The data from the other CPTU channels then also transmitted by cable. The seismic CPT cable is a shielded cable, different from the normal one (P.N. 08870).

8.2 Mud lubrication to reduce skin friction along the extension rods

Skin friction can be reduced by using a ring of larger diameter on top of the probe (so called friction reducer), or by pumping approximately 1liter of bentonite per push meter. By running CPT without a cable, the inner diameter of the extension rods can be used for pumping down bentonite.



Bentonite is prepared in the reservoir of a mud pump, which is connected with a hose to the mud adapter of the CPT microphone. The pump is activated as the test is started. The resulting reduction in skin friction is illustrated in Fig. 11, where a reaction force of 8 tons is reduced by 50% at 18 n depths.

Figure 11: Reduction of reaction force in CPT sounding by using mud lubrication. Geotech probe used in the Canadian Beaufort Sea (in Lunne et al. (1997)

8.3 CPT Tests in very soft grounds

Running CPT in very soft grounds, such as in tailings dams, it is highly recommended to run CPT test with casing tubes to avoid bending and breaking of rods as the probe would meet more consolidated layers at depth. In the absence of skin friction, the rods buckle with a load of 5 tons and a rod length of only 1,7 m. This is the Euler second formula for rods with both ends able to rotate where:

$$F_k = \pi^2 EI/l^2$$

and F_k = Applied axial force (N)
E = Elasticity modulus = $22.\ 10^{10}$ N/m^2
I = Surface moment of inertia = $\pi(OD^4\text{-}ID^4)/64$ (m^4)
l = Breaking length (m)

Running CPT with acoustic transmission of data and no cable simplifies the use of casing during testing. Casing tubes should be ID 39 mm.

In order to reduce the risk of bending and breaking of rods, a tilt increment alarm is available in the acquisition software CPT-LOG and is defined as degrees per meter. A normal triggering value should be approximately 60 degrees/meter. This function, when activated, will set the alarm several times each time a new sounding is started, before the probe has penetrated the ground.

For most soils, it is recommended to use a friction holder at the foot of the pushing equipment, to hold the rods from sinking by their own weight and to fall back in the hole, when pulling them up.

8.4 Offshore CPT

The standard CPT probes and sound transmitters can be used for offshore use. The normal water pressure range of the probe is 2.5 MPa, i.e. a 250 m water column. The other standard equipment items, microphone, depth encoder and interface box cannot be placed under water.

1. Soundings from boat decks or platforms

The standard equipment can be used in a normal way, using casing tubes, from deck to sea bottom, to avoid the bending of rods, like in very soft soils.

2 Soundings from sub sea platforms

In CPT soundings from sub sea platforms, generally all rods are assembled prior to the start of the sounding. The use of a cordless system does not in such case simplify the operation. The microphone and sound transmitter are replaced by a cable connection as under Cable CPT, here above.

The depth encoder is replaced by a watertight version with a wheel rotating against the rods, Fig. 12. The unit consists of:

- An outer part with the rotating wheel, which is loosened regularly for greasing of the bearings,
- An inner part which should under no circumstances be opened. It consists of a two couple of magnets, which transmit the rotation of the wheel through the watertight separation, the electronic unit with cable connections. The inner part does not require any maintenance.

Mounting of the depth encoder

Depth increments are only registered in one rotation direction. In order to establish the proper direction of rotation, connect the depth encoder and the CPT probe with the interface box and PC, start the acquisition program CPT-LOG and a simulated CPT test. In case no depths are recorded, turn the depth encoder upside down in order to change the direction of rotation.

Once the orientation of the encoder is established, mount the unit with a spring load, with a load of 4 kg on the rotary wheel against the CPT extension rods.

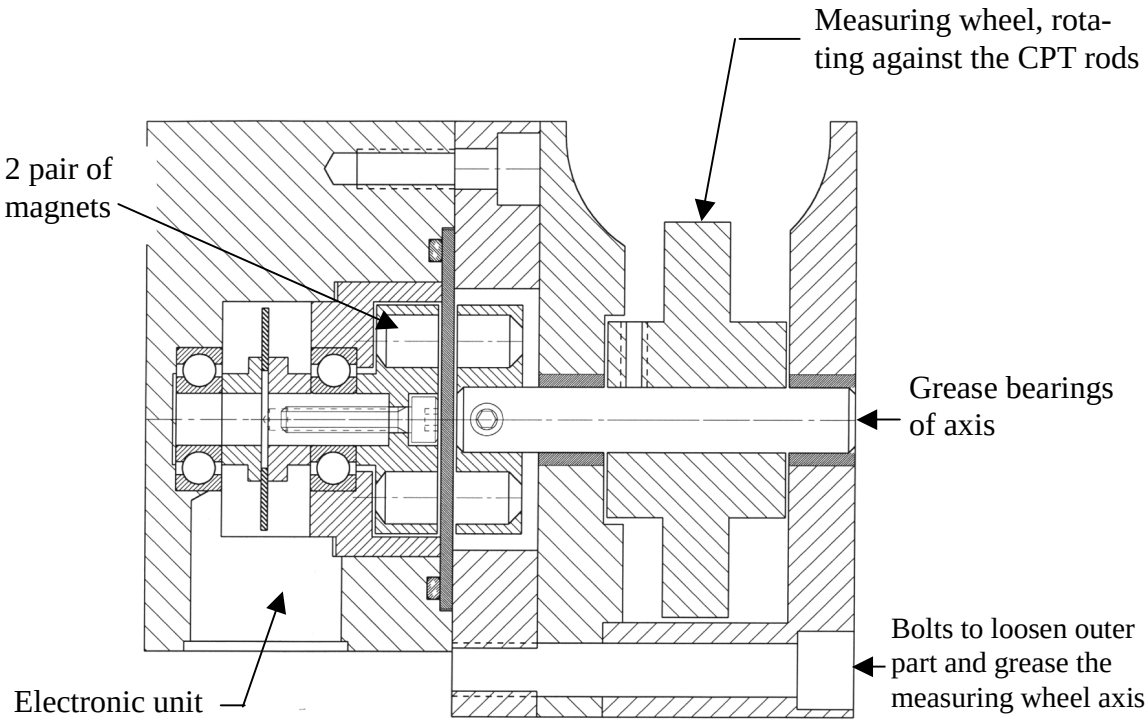

Measuring wheel, rotating against the CPT rods
2 pair of magnets
Grease bearings of axis
Bolts to loosen outer part and grease the measuring wheel axis
Electronic unit

Figure 12: Depth encoder for sub-sea use

The depth range of the depth encoder is 40 m.

Interface box and signal conditioning box

It is preferable to keep the signal conditioning box and interface box above sea level. The observation of the diodes of the interface box is a good monitoring of the CPT test. If not possible, the two boxes can be paced in a watertight caisson on the sub sea rig.